THEORY OF THE MOTION OF THE MOON.[1]

DR. BROWN, in the first two parts of his work, has explained his methods. The third part contains little more than tables of results. Our review, therefore, must be necessarily confined to an extension of the tables that have appeared in NATURE on November 25, 1897, and July 13, 1899. It will be seen that the high order of accuracy to which the computations have been pushed has been maintained, and that most of the latest series of terms are very small and, with a few exceptions, below the limits of observation.

Reference Number.	Characteristic.	Argument.	Number of Terms.	Approximate value in arc of the largest coefficient.	Value of unity in the last figure given in millionths of a second of arc.	Reference Number.	Characteristic.	Argument.	Number of Terms.	Approximate value in arc of the largest coefficient.	Value of unity in the last figure given in millionths of a second of arc.
1	1	0	13	206265″	0·0002	61	kea	$l+F+D$	10	0·1	0·2
2	e	l	18	17000	2	62	kea	$l-F+D$	10	0·2	0·2
3	e'	l'	21	350	0·4	63	$ke'a$	$l'+F+D$	10	0·2	0·003
4	a	D	9	80	0 05	64	$ke'a$	$l'-F+D$	10	0·5	0·003
5	k	F	11	9000	0·01	65	ka^2	F	8	0·004	0·06
6	e^2	$2l$	21	240	3	66	e^4	$4l$	13	0·6	32
7	e^2	0	11	340	3	67	e^4	$2l$	15	0·6	32
8	ee'	$l+l'$	21	140	4	68	e^4	0	9	0·5	32
9	ee'	$l-l'$	22	100	4	69	e^3e'	$3l+l'$	14	0·3	5
10	e'^2	$2l'$	18	6	0·6	70	e^3e'	$3l-l'$	14	0·3	5
11	e'^2	0	10	2	0·6	71	e^3e'	$l+l'$	16	0·4	5
12	k^2	$2F$	20	400	0·4	72	e^3e'	$l-l'$	17	0·5	5
13	k^2	0	11	400	0·4	73	$e^2e'^2$	$2l+2l'$	15	0·2	0·7
14	ea	$l+D$	19	12	0·6	74	$e^2e'^2$	$2l-2l'$	15	0·1	7
15	$e'a$	$l'+D$	20	14	0·1	75	$e^2e'^2$	$2l$	15	0·04	7
16	a^2	0	9	0·01	0·1	76	$e^2e'^2$	$2l'$	14	0·2	7
17	ke	$l+F$	10	15	0·06	77	$e^2e'^2$	0	9	0·07	0·7
18	ke	$l-F$	11	45	0·06	78	ee'^3	$l+3l'$	13	0·2	1
19	ke'	$l'+F$	10	1	0·01	79	ee'^3	$l-3l'$	14	0·03	1
20	ke'	$l'-F$	11	0·4	0·01	80	ee'^3	$l+l'$	15	0·05	1
21	ka	$F+D$	10	4	0·02	81	ee'^3	$l-l'$	14	0·07	1
22	e^3	$3l$	17	11	27	82	e'^4	$4l'$	11	0·01	0·16
23	e^3	l	18	11	27	83	e'^4	$2l'$	11	0·04	0·16
24	e^2e'	$2l+l'$	17	6	4	84	e'^4	0	7	0·0001	0·02
25	e^2e'	$2l-l'$	18	3	4	85	e^2k^2	$2l+2F$	13	0·5	5
26	e^2e'	l'	19	8	4	86	e^2k^2	$2l-2F$	14	1·7	50
27	ee'^2	$l+2l'$	16	5	0 6	87	e^2k^2	$2l$	16	1	50
28	ee'^2	$l-2l'$	15	2	0·6	88	e^2k^2	$2F$	15	2	50
29	ee'^2	l	17	1	0·6	89	e^2k^2	0	9	2	5
30	e'^3	$3l'$	13	0·3	0·01	90	$ee'k^2$	$l+l'+2F$	13	0·1	7
31	e'^3	l'	16	0·1	0·1	91	$ee'k^2$	$l+l'-2F$	14	0·1	7
32	ek^2	$l+2F$	15	11	4	92	$ee'k^2$	$l-l'+2F$	15	0·06	7
33	ek^2	$l-2F$	17	30	4	93	$ee'k^2$	$l-l'-2F$	14	0·4	7
34	ek^2	l	16	14	0·4	94	$ee'k^2$	$l+l'$	16	0·6	7
35	$e'k^2$	$l'+2F$	15	2	0·07	95	$ee'k^2$	$l-l'$	15	0·8	7
36	$e'k^2$	$l'-2F$	16	1	0·7	96	e'^2k^2	$2l'+2F$	11	0·04	0·1
37	$e'k^2$	l'	16	4	0·7	97	e'^2k^2	$2l'-2F$	13	0·01	1
38	e^2a	$2l+D$	18	0·8	0 6	98	e'^2k^2	$2l'$	13	0·06	1
39	e^2a	D	7	1·3	6	99	e'^2k^2	$2F$	13	0·03	1
40	$ee'a$	$l+l'+D$	16	0·4	1	100	e'^2k^2	0	7	0·03	0·1
41	$ee'a$	$l-l'+D$	16	0·8	1	101	k^4	$4F$	9	0·04	0 8
42	e'^2a	$2l'+D$	15	0·3	0·02	102	k^4	$2F$	11	0·8	8
43	e'^2a	D	8	0·4	0·2	103	k^4	0	7	0·8	0·8
44	k^2a	$2F+D$	16	0·5	0 1	104	e^3a	$3l+D$	15	0·06	7
45	k^2a	D	8	3	0·1	105	e^3a	$l+D$	16	0·13	7
46	ea^2	l	16	0·03	0·1	106	$e^2e'a$	$2l+l'+D$	12	0·05	10
47	$e'a^2$	l'	16	0·002	0·02	107	$e^2e'a$	$2l-l'+D$	12	0 2	10
48	a^3	D	8	0·001	0·03	108	$e^2e'a$	$l'+D$	12	0·4	10
49	k^3	$3F$	9	1	0·2	109	ee'^2a	$l+2l'+D$	10	0·06	1·4
50	k^3	F	8	0·2	0·2	110	ee'^2a	$l-2l'+D$	11	0·03	1·4
51	ke^2	$2l+F$	10	10	1	111	ee'^2a	$l+D$	12	0·06	1·4
52	ke^2	$2l-F$	10	9	1	112	e'^3a	$3l'+D$	11	0·001	0·2
53	ke^2	F	10	4	1	113	e'^3a	$l'+D$	12	0·002	0·2
54	kee'	$l+l'+F$	10	5	0·2	114	ek^2a	$l+2F+D$	12	0·02	0·1
55	kee'	$l+l'-F$	10	3	0 2	115	ek^2a	$l-2F+D$	15	0·02	1
56	kee'	$l-l'+F$	11	2	0 2	116	ek^2a	$l+D$	15	0 2	1
57	kee'	$l-l'-F$	11	4	0 2	117	$e'k^2a$	$l'+2F+D$	13	0·01	0·2
58	ke'^2	$2l'+F$	10	0·8	0 03	118	$e'k^2a$	$l'-2F+D$	14	0·01	0·2
59	ke'^2	$2l'-F$	10	0·08	0·3	119	$e'k^2a$	$l'+D$	15	0·2	0·2
60	ke'^2	F	10	0·4	0·03	120	e^2a^2	$2l$	12	0·002	20

[1] "Theory of the Motion of the Moon ; containing a New Calculation of the Expressions for the Coordinates of the Moon in Terms of the Time." By Ernest W. Brown, M.A., Sc.D., F.R.S. (From the *Memoirs* of the Royal Astronomical Society, vol. liii.)

Reference Number.	Characteristic.	Argument.	Number of Terms.	Approximate value in arc of the largest coefficient.	Value of unity in the last figure given in millionths of a second of arc.
121	e^2a^2	o	7	0·002	20
122	$ee'a^2$	$l+l'$	13	0·0006	0·2
123	$ee'a^2$	$l-l'$	14	0·001	0·2
124	k^2a^2	$2F$	11	0·001	2
125	k^2a^2	o	7	0·001	0·2
126	ke^3	$3l+F$	8	0·5	1
127	ke^3	$3l-F$	8	0·3	1
128	ke^3	$l+F$	9	0·7	1
129	ke^3	$l-F$	9	0·7	1
130	ke^2e'	$2l+l'+F$	8	0·2	0·2
131	ke^2e'	$2l-l'-F$	8	0·1	2
132	ke^2e'	$2l-l'+F$	8	0·1	2
133	ke^2e'	$2l-l'-F$	9	0·1	2
134	ke^2e'	$l'+F$	9	0·3	2
135	ke^2e'	$l'-F$	9	0·2	2
136	kee'^2	$l+2l'+F$	8	0·2	0·03
137	kee'^2	$l+2l'-F$	8	0·1	0·03
138	kee'^2	$l-2l'+F$	8	0·1	0·03
139	kee'^2	$l-2l'-F$	8	0·1	0·03
140	kee'^2	$l+F$	8	0·04	0·03
141	kee'^2	$l'-F$	9	0·02	0·03
142	ke'^3	$3l'+F$	6	0·02	0·004
143	ke'^3	$3l'-F$	8	0·002	0·04
144	ke'^3	$l'+F$	8	0·01	0·04
145	ke'^3	$l'-F$	8	0·002	0·04
146	k^3e	$l+3F$	7	0·1	0·2
147	k^3e	$l-3F$	7	1·0	0·2
148	k^3e	$l+F$	8	0·5	0·2
149	k^3e	$l-F$	8	4·3	0·2
150	k^3e'	$l'+3F$	6	0·05	0·03
151	k^3e'	$l'-3F$	7	0·03	0·3
152	k^3e'	$l'+F$	8	0·08	0·3
153	k^3e'	$l'-F$	7	0·08	0·3
154	ke^2a	$2l+F+D$	8	0·03	0·03
155	ke^2a	$2l-F+D$	9	0·06	0·03
156	ke^2a	$F+D$	9	0·07	0·03
157	$kee'a$	$l+l'+F+D$	7	0·02	0·4
158	$kee'a$	$l+l'-F+D$	7	0·005	4
159	$kee'a$	$l-l'+F+D$	7	0·007	4
160	$kee'a$	$l-l'-F+D$	7	0·017	4
161	ke'^2a	$2l'+F+D$	6	0·001	0·006
162	ke'^2a	$2l'-F+D$	8	0·001	0·006
163	ke'^2a	$F+D$	8	0·0004	0·006
164	k^3a	$3F+D$	7	0·01	0·004
165	k^3a	$F+D$	8	0·06	0·004
166	kea^2	$l+F$	7	0·001	0·006
167	kea^2	$l-F$	7	0·0005	0·006
168	$ke'a^2$	$l'+F$	7	0·0002	0·01
169	$ke'a^2$	$l'-F$	7	0·0002	0·01

HOW THE SABRE-TOOTHED TIGERS KILLED THEIR PREY.

DURING the greater portion of the third or last great geological epoch—the Tertiary period of geologists—there flourished certain very large and powerful members of the cat tribe, commonly known, on account of the inordinate length of their upper tusks, as sabre-toothed tigers, although there is nothing to show that they had any more affinity with the tiger than with the lion. Indeed, they were widely separated structurally from both, as they were from all living cats. In these sabre-tooths the upper tusks were huge, compressed, scimitar-shaped teeth, with the front and back edges generally, if not always, finely serrated. In some of the later species, which existed contemporaneously with man, the upper tusks were eight or nine inches in length, and they were longest of all in a South American species. In the earlier members of the group, before they had attained the inordinate development characterising the later forms, the upper tusks were protected by a descending flange at the fore part of each side of the lower jaw. Apparently, however, this was not found to be a satisfactory working arrangement, and it was accordingly discarded in the later forms, the tusks of which became proportionately thicker so as to stand in need of no such protection. At the same time the whole lower jaw became remarkably slender and weak, so much so, indeed, that it is evident it could not have been used in the same manner as the lower jaw of a lion or a tiger. Confirmation of this view is afforded by the circumstance that the lower jaw articulates with the skull in quite a different way from that which occurs in the last-mentioned animals.

Sabre-tooths were distributed over a great portion of the surface of the globe, their remains having been found in England, France, Germany, Hungary, Greece, Persia, India and North and South America. They lived at first at a time when true cats were either very scarce or entirely unknown, and they appear to have survived longest in South America.

A moment's consideration will show that, at any rate in the case of the longest-tusked species, it was quite impossible for these animals to bite in the ordinary manner, as the entrance to the mouth would be barred by the tusks, which must have reached to the sides of the lower jaw if the extent of the gape were only equal to that of a lion or a tiger.

This disability has given rise to several suggestions as to the mode in which the sabre-tooths used their upper tusks. One idea was that they were employed as stabbing weapons, and used while the mouth is closed. With the earlier forms, in which the tusks were shorter and protected by a flange on the lower jaw, this method of use would obviously be an impossibility. Moreover, as is pointed out by a writer whose name will be mentioned later on, it would involve, after long adaptation to striking with the mouth open, a sudden change to attacking with the jaw closed. Perhaps a still more serious objection is the fact that the efficient length of the weapon would be diminished by about a half if the attack were made with the jaw shut, and therefore that the animals might just as well have remained in their primitive form, with comparatively short tusks. Again, the closed mouth would obviously be a very serious disadvantage to an animal which drinks the blood of its victims.

Among other strange suggestions, it has been supposed that the tusks were employed as aids in climbing trees ! Apart from other considerations, their brittle structure and finely serrated edges would render them obviously unsuited for this purpose. Another idea is that the sabre-tooths were aquatic in their habits, and that their tusks were used in some respects in the same manner as are those of the walrus. Needless to say, this idea, although difficult to disprove in so many words, may be dismissed without serious comment. It may be added that the long tusks of the later and more specialised sabre-tooths have actually been regarded as the cause of the extinction of the group, the idea being that the creatures, owing to the entrance being barred by the tusks, could not open their mouths sufficiently wide to admit food.

Recently, in the *Memoirs* of the American Museum of Natural History, Mr. W. D. Matthew has suggested an explanation of the puzzle, which, although somewhat startling to preconceived ideas, seems on the whole to be the best solution of the problem hitherto offered. Starting with the indisputable fact that the mode of articulation of the lower jaw to the skull is quite different from that which obtains in the true cats, and also bearing in mind the weakness of the lower jaw itself and the smallness of its tusks, the author suggests that the sabre-tooths dropped the lower jaw into a vertical position, and were thus enabled to use their upper tusks as stabbing weapons. An examination of the skull of the large South American species in the British Museum shows that such a position of the lower jaw is quite possible, the small size of its ascending or coronoid branch allowing the necessary movement to be made without interfering with the cheek-arches.

"Presumably," adds the author, "the ligaments were adjusted to these changes, and if so, there appears to be no reason why the sabre-tooth should not open his mouth far wider than is possible for the cat, laying back the chin against the throat without inconvenience. Along with this change there is a decrease in power of the muscles closing the jaw, due probably to lack of use of the lower canines (used against the upper ones in other Carnivora, but useless in this way to the sabre-tooth)."